Generation Interconnection Combined Feasibility/System Impact Study Report

For

PJM Generation Interconnection Request Queue Position AC1-020

"Kittatinny-Newton 34.5 kV"

March 2017

Preface

The intent of the Combined Feasibility/System Impact Study is to determine a plan, with approximate cost and construction time estimates, to connect the subject generation interconnection project to the PJM network at a location specified by the Interconnection Customer. As a requirement for interconnection, the Interconnection Customer may be responsible for the cost of constructing: Network Upgrades, which are facility additions, or upgrades to existing facilities, that are needed to maintain the reliability of the PJM system. All facilities required for interconnection of a generation interconnection project must be designed to meet the technical specifications (on PJM web site) for the appropriate transmission owner.

In some instances an Interconnection Customer may not be responsible for 100% of the identified network upgrade cost because other transmission network uses, e.g. another generation interconnection or merchant transmission upgrade, may also contribute to the need for the same network reinforcement. The possibility of sharing the reinforcement costs with other projects may be identified in the Feasibility Study, but the actual allocation, if any, is included in the System Impact Study.

The Study estimates do not include the feasibility, cost, or time required to obtain property rights and permits for construction of the required facilities. The project developer is responsible for the right of way, real estate, and construction permit issues. For properties currently owned by Transmission Owners, the costs associated with them will be addressed when seeking an Interconnection Agreement as outlined below. Developer will also be responsible for providing and installing metering equipment in compliance with applicable PJM and Transmission Owner standards.

General

Advanced Solar Products PV1 LLC, the Interconnection Customer (IC), has proposed a solar generating facility located near Newton Airport, Stickels Pond Road, in Newton, New Jersey. The installed facilities will have a total capability of **12.2 MW** with **4.6 MW** of this output being recognized by PJM as capacity. The proposed in-service date for this project is **September 1, 2017**. **This study does not imply a Jersey Central Power & Light (JCPL) commitment to this in-service date.**

Point of Interconnection

AC1-020 "Kittatinny-Newton 34.5 kV" will be located at a new tap connection to the Blairstown-East Newton segment of the Kittatinny-Newton M715 34.5 kV line 1.2 miles away from East Newton substation. Attachment 1 provides an aerial view of the proposed location of the facility. The direct connection of AC1-020 "Kittatinny-Newton 34.5 kV" will be accomplished by establishing a radial tap point along the M715 line, extending the tap approximately 300ft to the developer's pole designated as the POI, installing SCADA controlled switches on all three lines extending from the new tap point, and installing metering on a pole provided by the developer beyond the POI. No alternate point of interconnection was requested

to be studied, therefore a secondary point of interconnection was not analyzed. Attachment 2a and 2b show a conceptual one-line diagram of the proposed connection of AC1-020 "Kittatinny-Newton 34.5 kV" to the JCPL transmission system. Advanced Solar Products PV1 LLC will be responsible for constructing all of the facilities on its side of the POI including the attachment line. Advanced Solar Products PV1 LLC may not install above ground equipment within any JCPL right-of-way unless permission to do so is expressly granted by JCPL. The JCPL facilities required to be upgraded for the Direct Connection of the generation project and the associated cost estimates are detailed below.

Cost Summary

The **AC1-020** "Kittatinny-Newton 34.5 kV" project will be responsible for the following costs. These costs do not include CIAC Tax Gross-up.

Description	Total Cost
Attachment Facilities	$ 219,648
Direct Connection Network Upgrades	$ 445,952
Non Direct Connection Network Upgrades	$ 52,000
New System Upgrades	$ 0
Previously Identified Upgrades	$ 0
Total Costs	**$ 717,600**

The required Attachment Facilities, Direct Connection, and Non-Direct Connection work for the interconnection of the AC1-020 "Kittatinny-Newton 34.5 kV" generation project to theJCPL Transmission System is detailed in the following sections. The associated one-lines with the generation project attachment facilities and primary direct connection are shown in Attachments 2A and 2B.

Note that all cost estimates contained in this document were produced without a detailed engineering review and are therefore subject to change. Advanced Solar Products PV1 LLC will be responsible for the actual cost of the direct connection that is implemented. JCPL herein reserves the right to return to any issues in this document and, upon appropriate justification, request additional monies to complete any reinforcements to the transmission systems.

Notes:

- The IC will be responsible for obtaining any necessary environmental permits.
- The IC will be responsible for the crossing of a PSE&G bulk transmission line Right-of-Way in the vicinity of the POI.
- Any right-of-way necessary to construct the IC's line must be obtained by the IC.

Attachment Facilities

AC1-020 "Kittatinny-Newton 34.5 kV" will interconnect to the JCPL transmission system at a point approximately 1.2 miles from the existing East Newton substation facility along the Kittatinny-Newton 34.5 kV line. The direct connection of AC1-020 "Kittatinny-Newton 34.5 kV" will be accomplished by establishing a radial tap point along the M715 line, extending the tap approximately 300ft to the developer's pole designated as the POI, installing SCADA controlled switches on all three lines extending from the new tap point, and installing metering on a pole provided by the developer beyond the POI.

The Attachment Facility work is considered to be the installation of the one tap switch and one 300 ft span to the point of interconnection with the AC1-020 customer along the generator lead line including metering.

The total preliminary cost estimate for the Attachment work is given in the table below. These costs do not include CIAC Tax Gross-up.

Description	Total Cost
Tap the Kittatinny-Newton (M715) 34.5 kV line nearest Newton Airport on Stickles Pond Road to serve 12.2 MW solar generation facility in Andover Twp, Sussex County, NJ. Install 1 SCADA switch on the tap including metering. Partial cost of the secondary power feed from the distribution supply to the SCADA switch is included. **PJM Network Upgrade Number n5227.**	$ 219,648
Total Attachment Facilities Cost	**$ 219,648**

Direct Connection Cost Estimate

The Direct Connection work is considered to be the installation of the two 34.5 kV gang-operated SCADA controlled switches on either side of the tap to the AC1-020 customer. These switches are in network with the JCPL Kittatinny-Newton 34.5 kV line.

The total preliminary cost estimate for the Direct Connection work is given in the table below. These costs do not include CIAC Tax Gross-up.

Description	Total Cost
Install 2 new SCADA switches on new poles in the Kittatinny-Newton (M715) 34.5 kV line at the tap point to AC1-020 customer. Partial cost of the secondary power feed from the distribution supply to the SCADA switch is included. **PJM Network Upgrade Number n5228.**	$ 445,952
Total Direct Connection Cost	**$ 445,952**

Non-Direct Connection Cost Estimate

The Non-Direct Connection work will include relay setting adjustments and functional testing on the 34.5 kV on the Kittatinny-Newton 34.5 kV line at both Kittatinny and Newton Substations for the interconnection of the AC1-020 IC.

The total preliminary cost estimate for the Non-Direct Connection work is given in the table below. These costs do not include CIAC Tax Gross-up.

Description	Total Cost
Adjust relay settings on Newton line exit @ Kittatinny SS **PJM Network Upgrade Number n5229.**	$ 26,000
Adjust relay settings on Kittatinny line exit @ Newton SS **PJM Network Upgrade Number n5230.**	$ 26,000
Total Non-Direct Connection Cost	**$ 52,000**

Interconnection Customer Requirements

In addition to the JCPL facilities, Advanced Solar Products PV1 LLC will also be responsible for meeting all criteria as specified in the applicable sections of the FE "Requirements for Transmission Connected Facilities" document including:

1. The purchase and installation of fully rated PJM kV circuit breaker on the high side of the AC1-020 "Kittatinny-Newton 34.5 kV" step-up transformer.

2. The purchase and installation of the minimum required FE generation interconnection relaying and control facilities. This includes over/under voltage protection, over/under frequency protection, and zero sequence voltage protection relays.

3. The purchase and installation of supervisory control and data acquisition ("SCADA") equipment to provide information in a compatible format to the FE Transmission System Control Center.

4. The establishment of dedicated communication circuits for SCADA to the FE Transmission System Control Center.

5. A compliance with the FE and PJM generator power factor and voltage control requirements.

6. The execution of a back-up service agreement to serve the customer load supplied from the AC1-020 "Kittatinny-Newton 34.5 kV" generation project interconnection point when the units are out-of-service. This assumes the intent of Advanced Solar Products PV1 LLC is to net the generation with the load.

The above requirements are in addition to any metering or any other requirements imposed by PJM.

Schedule

Based on the extent of the FE primary Direct Connection and system upgrades required to support the AC1-020 "Kittatinny-Newton 34.5 kV" generation project, it is expected to take a minimum of **ten (10) months** from the date of a fully executed Interconnection Construction Service Agreement to complete the installation. This includes the requirement for Advanced Solar Products PV1 LLC to make a preliminary payment to FE which funds the first three months of engineering design that is related to the construction of the Direct Connection facilities. It further assumes that Advanced Solar Products PV1 LLC will provide all rights-of-way, permits, easements, etc. that will be needed. A further assumption is that there will be no environmental issues with any of the new properties associated with this project, that there will be no delays in acquiring the necessary permits for implementing the defined Direct Connection, and that all system outages will be allowed when requested.

Note that the FE findings were made from a conceptual review of this project. Further note that the cost estimate data contained in this document should be considered high level estimates since it was produced without a detailed engineering review. The applicant will be responsible for the actual cost of construction. FE herein reserves the right to return to any issues in this document and, upon appropriate justification, request additional monies to complete any reinforcements to the transmission system.

Revenue Metering and SCADA Requirements

PJM Requirements

The Interconnection Customer will be required to install equipment necessary to provide Revenue Metering (KWH, KVARH) and real time data (KW, KVAR) for IC's generating Resource. See PJM Manuals M-01 and M-14D, and PJM Tariff Sections 24.1 and 24.2.

JCPL Requirements

Advanced Solar Products PV1 LLC will be required to comply with all FE revenue metering requirements for generation interconnection customers. The FE revenue metering requirements may be found in the FE "Requirements for Transmission Connected Facilities" document located at the following link:

http://www.pjm.com/planning/design-engineering/to-tech-standards/private-firstenergy.aspx

Compliance Issues

The proposed interconnection facilities must be designed in accordance with the FE "Requirements for Transmission Connected Facilities" document located at:

http://www.pjm.com/planning/design-engineering/to-tech-standards/private-firstenergy.aspx

Advanced Solar Products PV1 LLC will also be responsible for following the requirements of the FE "Approved Vendors and Contractors" document which is also located at the above link.

Advanced Solar Products PV1 LLC will also be required to meet all PJM, ReliabilityFirst and NERC reliability criteria and operating procedures for standards compliance. For example, Advanced Solar Products PV1 LLC will need to properly locate and report the over and under voltage and over and under frequency system protection elements for its units as well as the submission of the generator model and protection data required to satisfy the PJM and ReliabilityFirst audits. Failure to comply with these requirements may result in a disconnection of service if the violation is found to compromise the reliability of the JCPL system.

JCPL Analysis:

Power Flow Analysis

A power flow study was conducted to determine the reliability impact of the proposed AC1-020 "Kittatinny-Newton 34.5 kV" generation project on the JCPL transmission system. The findings and the recommendations from this analysis are based on a contingency review that was performed to identify the facility loadings and/or voltage conditions that violate the ReliabilityFirst, PJM, or FE Planning Criteria and are attributable to this project. Any such violation that is either directly attributable to this project or for which it will have a shared responsibility is included in this report with a least cost plan identified to mitigate the violation.

The power flow analysis was performed using a 2020 summer peak load base case provided by the PJM staff. This base case included a detailed representation of the Jersey Central Power & Light transmission networks in the area of the proposed AC1-020 "Kittatinny-Newton 34.5 kV" generation project. A simulation of all single, bus, stuck breaker and common structure contingencies within the NERC and FE Planning Standards that are impacted by the project was conducted to test for criteria compliance. Note that in accordance with PJM RTEP study procedures, the AC1-020 "Kittatinny-Newton 34.5 kV" generation project under study and earlier active queue projects are considered to be in service. Therefore, all active queue projects after the AC1-020 "Kittatinny-Newton 34.5 kV" generation project are considered not in service.

For the POI (see Attachment 2a and 2b), the AC1-020 "Kittatinny-Newton 34.5 kV" generation project was studied with a connection to the Blairstown-East Newton segment of the Kittatinny-Newton M715 34.5 kV line 10% away from East Newton. The results of the FE analysis of the summer peak load base case show that there are no transmission network upgrades required for the deliverability of the AC1-020 "Kittatinny-Newton 34.5 kV" project generation to the JCPL transmission systems.

A light load power flow study was conducted to determine the reliability impact of the proposed AC1-020 "Kittatinny-Newton 34.5 kV" generation project on the JCPL transmission system. The findings and the recommendations from this analysis are based on a contingency review that was performed to identify the facility loadings and/or voltage conditions that violate the ReliabilityFirst, PJM, or FE Planning Criteria and are attributable to this project. No thermal violations were identified as part of the light load analysis. The open ended line contingency, loss of the East Newton source to the M715 line, causes a voltage violation when the generators' power factors along this line are held at unity and the generators are supplying energy into the system. This facility shall be designed with the ability to dynamically maintain a power factor of at least 0.95 leading to 0.95 lagging measured at the generator's terminals. This requirement serves to resolve the identified voltage violation.

Review of the AC1-020 Data Sheet provided did not list the total reactive power capability at maximum gross energy output. Note that a further conclusion of this study is that it will be mandatory for the AC1-020 "Kittatinny-Newton 34.5 kV" generation project to have a range of dynamic reactive capability that supports its operation from a 0.95 leading to 0.95 lagging power factor measured at the generator's terminals. The FE studies show that the addition of inverter based projects without continuous regulation can cause significant voltage swings in conjunction with system operating conditions and other inverter based generation, and system voltages can exceed the established limits. Should Advanced Solar Products PV1 LLC fail to provide dynamic reactive capability from the AC1-020 "Kittatinny-Newton 34.5 kV" generation project for any reason once interconnected, the FE and/or PJM Dispatchers may need to take action to curtail output to prevent non-compliance with voltage criteria.

Short Circuit and Dynamics Analysis

In accordance with the RTEP process, a short circuit analysis was not conducted by PJM since the AC1-020 "Kittatinny-Newton 34.5 kV" Project connection is to the Jersey Central Power & Light less than 100 kV transmission system, the project is less than or equal to 20 MW and is a inverter based (solar, flywheel, battery etc) project. Therefore, the FE Protection staff conducted a short circuit review of the project connection.

Section 14.2.6 of the FE "Requirements for Transmission Connected Facilities" document states that the winding configurations for the transformer connecting to a non-effectively grounded portion of the FE Transmission System shall be determined by FE on a case by case basis. This project, modeled per the filed Data Sheet indicates a delta connection on the 34.5 kV side of the transformation. Evaluating this connection of the AC1-020 "Kittatinny-Newton 34.5 kV" generation project to the 34.5 kV system indicated there were no over-duty breakers. The contribution of fault currents to the system by this project were minimal. Therefore no circuit breaker reinforcements will be required.

A dynamics study was not performed for the AC1-020 "Kittatinny-Newton 34.5 kV" generation project since it is an inverter based project less than 70 MW.

System Protection Analysis

An analysis was conducted to assess the impact of the generation project on the system protection requirements in the area. The results of this review have identified the following:

- JCPL will have standard 34.5 kV line protection for the Kittatinny-Newton M715 34.5 kV line to add the Advanced Solar Products PV1 LLC 34.5 kV facility.
- A breaker is required at the POI which will clear for faults on the customer side beyond the POI breaker.
- At the POI the developer shall provide two relays, primary and back-up protection relays that provide fault protection for faults on the customer side that trips the breaker at the POI. The developer is responsible to provide fault protection to their equipment.
- Two levels of anti-island protection are required, inverters provide one level if they meet IEEE 1547.1 testing requirements, and an intertie relaying should provide the other level. Intertie relaying (over and under voltage, over and under frequency and ground detector elements) could be a third SEL-351 relay but it is acceptable that these functions are placed inside the SEL-351-7s that are used for fault protection. If inverter doesn't meet IEEE 1547.1 testing requirements DTT will be required.

Generation facilities that comply with IEEE-1547 and are UL 1741 certified or provide documentation by a third party testing organization of successful testing of the proposed inverter equipment in accordance with IEEE-1547.1 that are connected to the FE Transmission System below 100 kV meet one level of anti-island protection and are required to have a second level of protection.

The X/R ratio and the fault currents at the designated point are shown below.

	Three-Phase	**Single-Line**
X/R Ratio	4.3955	4.3800
Fault Current (Amps)	10,570	3,285

These values are for the current system configuration. Any system changes in the area could have a significant impact on these values. It will be the responsibility of the Interconnection Customer to make any protection upgrades required should this occur. The proposed interconnection facilities must be designed in accordance with the FE "Requirements for Transmission Connected Facilities" document.

Network Impacts (by PJM)

The Queue Project **AC1-020** "Kittatinny-Newton 34.5 kV" was evaluated as a **12.2 MW** (**Capacity 4.6 MW**) injection tapping the Blairtown- East Newtown portion of the Kittatinny-Newton 34.5kV line (Y1-084 Tap) in the JCPL area. Project AC1-020 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AC1-020 was studied with a commercial probability of 100%. Potential network impacts were as follows:

Generator Deliverability

(Single or N-1 contingencies for the Capacity portion only of the interconnection)

None.

Multiple Facility Contingency

(Double Circuit Tower Line contingencies were studied for the full energy output. The contingencies of Line with Failed Breaker and Bus Fault will be performed for the Impact Study.)

None.

Contribution to Previously Identified Overloads

(This project contributes to the following contingency overloads, i.e. "Network Impacts", identified for earlier generation or transmission interconnection projects in the PJM Queue)

None.

Steady-State Voltage Requirements

(Summary of the VAR requirements based upon the results of the steady-state voltage studies)

None.

Short Circuit

(Summary of impacted circuit breakers)

None.

Affected System Analysis & Mitigation

(Summary of impacts on systems external to PJM)

None

Delivery of Energy Portion of Interconnection Request

PJM also studied the delivery of the energy portion of this interconnection request. Any problems identified below are likely to result in operational restrictions to the project under study. The developer can proceed with network upgrades to eliminate the operational restriction at their discretion by submitting a Merchant Transmission Interconnection request.

Note: Only the most severely overloaded conditions are listed below. There is no guarantee of full delivery of energy for this project by fixing only the conditions listed in this section. With a Transmission Interconnection Request, a subsequent analysis will be performed which shall study all overload conditions associated with the overloaded element(s) identified.

None.

Light Load Analysis

Light Load Studies to be conducted during later study phases (applicable to wind, coal, nuclear, and pumped storage projects).

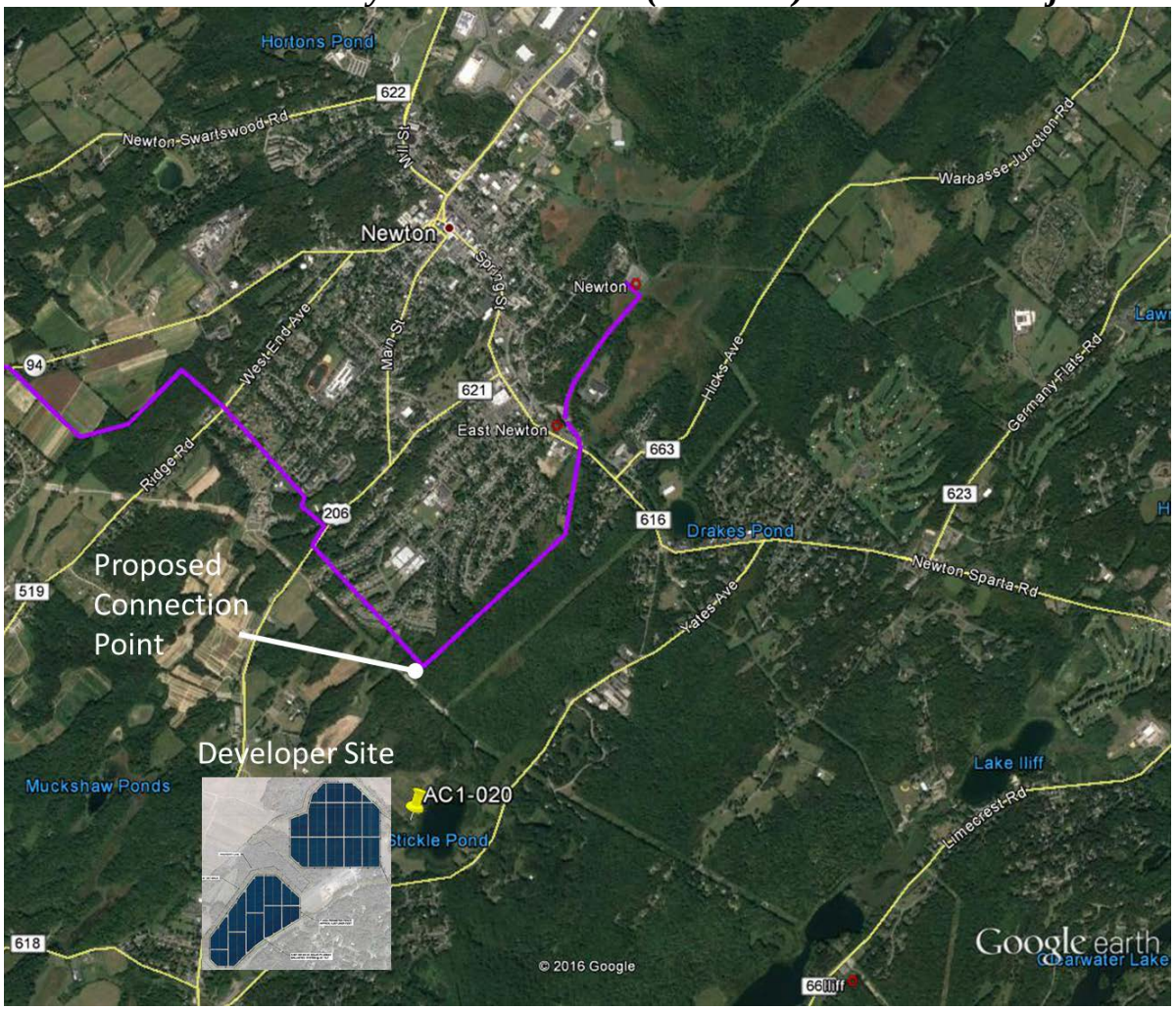
None.

Stability and Reactive Power Requirement for Low Voltage Ride Through

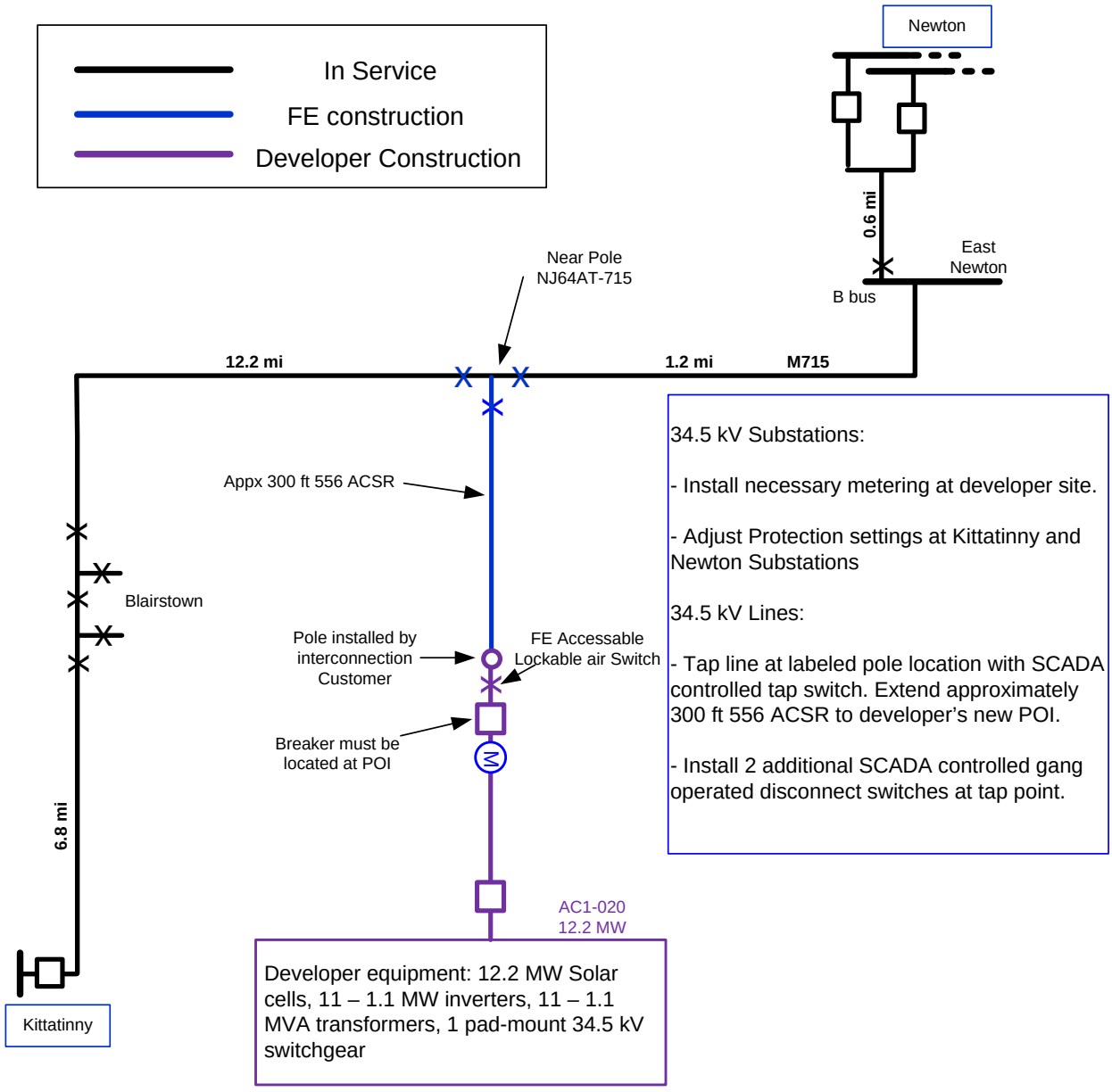
(Summary of the VAR requirements based upon the results of the dynamic studies)

None

Attachment 1
Project Location
Kittatinny-Newton 34.5 kV (AC1-020) Generation Project



Attachment 2A
Planning Interconnection Single Line Diagram
Kittatinny-Newton 34.5 kV (AC1-020) Generation Project



Attachment 2B
Proposed Interconnection Single Line Diagram
AC1-020 "Kittatinny-Newton 34.5 kV" Generation Project